DSSCOP: A DECISION SUPPORT SYSTEM FOR CORPORATE PLANNING

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CERTIFICATE

This is to certify that this work entitled ' DSSCOP: A DECISION SUPPORT SYSTEM FOR CORPORATE PLANNING', by Mr. B.M. Narayan, has been carried out under my supervision and that it has not been submitted elsewhere for the award of a degree.

April, 1985.

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ABSTRACT

Decision Support System for Corporate Planning (DSSCOP).: This system comprises three subsystems namely, forecasting, production and finance. In forecasting subsystem the exponential smoothing models are selected for demand forecasting, while optimization model is used for demand manipulation. The production planning subsystem meets these planned demands by an optimum production plan incurring minimum costs. Finally the finance subsystem does the financial analysis of these operations using financial statements and ratios.

This system is illustrated for a multiproduct company manufacturing 5 products and having the sales data of these products for the last 10 years, using fictitious data.

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CHAPTER I

INTRODUCTION

1.1 DECISION SUPPORT SYSTEMS:

The business environment is becoming increasingly competitive day by day and the survival in such an environment has become the single most important aim of all business organizations. To be able to manage effectively, the managements developed a strong thirst for information. This led to the usage of various computer based information systems (CBIS). One such system has survived for a long time, which is popularly known as management information systems (MIS). Though, it started with high hopes of fulfilling all the information requirements of management, it ended up in efficiently processing only the structured information. Moreover it imposed a structure on the operating methods and needed some programming skills. Thus the managers used to get reports through somebody else, which did not reflect the managers' thinking completely. To bridge this communication gap between managers' thinking and the information system performance, Decision Support Systems (DSS) were thought of .

A DSS is an interactive system that provides the user with easy access to decision models and data in order to support semi-structured or unstructured decision making tasks [16]. The stress is on supporting rather than replacing decision making.

A task is said to be unstructured when [3]:

1) Objectives are ambiguous and non-operational or objectives are relatively operational but numerous and conflicting.

2) It is difficult to determine the cause of changes in decision outcomes and to predict the effect on decision outcomes of the actions taken.

3) It is uncertain as to what actions taken by the decisiton maker might affect decision outcomes.

The focus here is on objectives. The unstructured tasks are unable to connect the user actions with favourable decision outcomes in any deterministic way. In other words even though it is known that some action is required to obtain and use information for decision making, we can not prove that a given set of actions is essentially linked to the final quality of the decision outcome.

The success of an interactive computer system depends to a large extent on a good human / computer interface. It is all the more important for a DSS that the user and the system interact in a conversational mode to supplement the users judgement with the analytical power of a computer. Since most of the unstructured problems are faced by higher levels of management, who are usually non-computer professionals, the interface should be comfortable for them to use the system.

1.2 SCOPE OF THE THESIS :

This thesis describes the design and implementation of a prototype DSS for corporate planning [DSSCOP] in a manufacturing organization.

The corporate planning activity in an organization provides a good model for an unstructured or semistructured task. Also the task is performed by higher level managers who are not expected to know programming skills nor are able to do the task without the help of a fast tool like a computer.

The main emphasis is on the design of a DSS, in an easy-to-use way and also incorporating operations research techniques into a classical corporate planning model. This enables the user to have more alternatives by searching a

wider decision domain.

1.3 ORGANIZATION OF THESIS:

Chapter II describes the decision support systems in more detail including the current research going on in this area.

Chapter III deals with corporate planning methods which are in use and introduces the corporate planning process in broad terms.

Chapter IV deals with the considerations involved in designing DSSCOP.

Chapter V deals with the actual model that is implemented on DEC-1090 system. The data for the model is fictitious , but representative of real life data .

Finally Chapter VI deals with conclusions drawn from the current exercise.

An example session with DSSCOP appears in appendix at the end.

CHAPTER II

DECISION SUPPORT SYSTEMS

2.1 STATE OF THE ART [4] :

DSS research is currently going on in five principal areas:

1) Knowledge based systems :

The purpose of knowledge based DSS is to capture the knowledge of the members of an organization about causal relationships in the organization and to draw inferances from this knowledge. This area overlaps with expert systems in artificial intelligence (A I).

2) Model Management :

Development of frameworks for model management systems similar to those for Data base management systems (DBMS). With the observation of importance of decision models, just like data, model management also became an important organizational resource. There are 2 areas of research in model management corresponding to the CODASYL frame work and the relational framework for data management.

3) Information Management:

The recognition of need to integrate data retrieval and calculation procedures has stimulated research to produce an emerging science of information management.

4) Information Economics:

Interest in enhancing the current concepts in information economics to provide relevant criteria for evaluating proposed or existing DSS has made the research necessary in this area.

5) Behavioural Issues:

Behavioural research on DSS is an outgrowth of the behavioural research done during the past decade on MIS. It is to investigate the behavioural issues relevant to the design and implementation of DSS.

Many successful implementations of DSS are reported in the literature [4,12,14]. In India also many academic institutions and manufacturing concerns have taken up this activity seriously in the recent past. Since this field is an emerging one, the picture is not very clear. Many very well structured problems which do not qualify for a DSS are termed DSS [4].

2.2 WHY DSS ? [13]:

The business organization is becoming and will increasingly become a highly automated man/ machine system and the nature of management will surely be conditioned by the character of the system being managed. There are great deal of similarities among the several potential areas of automation - blue colar, clerical and managerial. Perhaps the automated executive of the future has a great deal in common with the automated worker or clerk whom we observe in many situations today.

The technology has made it possible to simulate human brain atleast partly. We are acquiring technical capability to replace humans with computer in a rapidly widening range of ' thinking ' and ' deciding' tasks. The purpose is direct enhancement of human intelligence by giving a deeper understanding of how the human mind works and indirect enhancement of human intelligence by augmenting it with the artificial intelligence of computers.

Problems faced by management are distributed continuouslv between very well structured and highly unstructured ones. These tasks are progressively being automated. As a result the management will think of tomorrow rather than today as the day-to-day activities will be more or less automated.

There are 4 phases in the decision-making process:-

1) Intelligence activity : exploration, collection of data etc.

2) Design activity : inventing, developing, analysis.

3) Choice activity : selecting the best course of action among the various alternatives.

4) Review activity : assessing the past choices

Each of these activities may be structured or unstructured to form different combinations.

A successful decision maker goes through these phases carefully. The decisions are not any strange happenings , but they are taken by someone who knows about the problem better than others. Hence these skills are as learnable and trainable as the skills involved in driving, playing etc. As previously mentioned a decision maker's understanding is augmented by artificial means like providing various models and enlarging the domain in the decision space for better search of alternatives. This enhancement of knowledge about the problem results in better quality decisions on the part of the decision maker. An implication of DSS is that by externalizing the decision process, the decision maker can teach others the process he goes through so that

both he and his organization learn from his decisions.

An executives responsibility in a business organization is not only making decisions himself, but also seeing that the organization he directs makes decisions effectively. There is no reason to expect that a person who has acquired a fairly high level of skill in decision making activity will have a correspondingly high skill in designing efficient decision making systems. It is like supposing that a man, who is a good weight lifter can therefore design cranes. The skills of designing and maintaining of modern decision making systems are less intuitive. Hence they are even more susceptible to training than the skills of personal decision making.

Traditionally the structured tasks were carried out by formal training and planned experience of personnel. For improving the solving of unstructured problems, men of proven ability (experts) were relied upon. After the second world war many new techniques have been developed to solve structured problems. They are operations research, management science, mathematical programming etc. Unlike in structured problems we do not have a cut and dried method to solve unstructured problems. When we run out of ideas for handling poorly structured problem-solving tasks, we closely

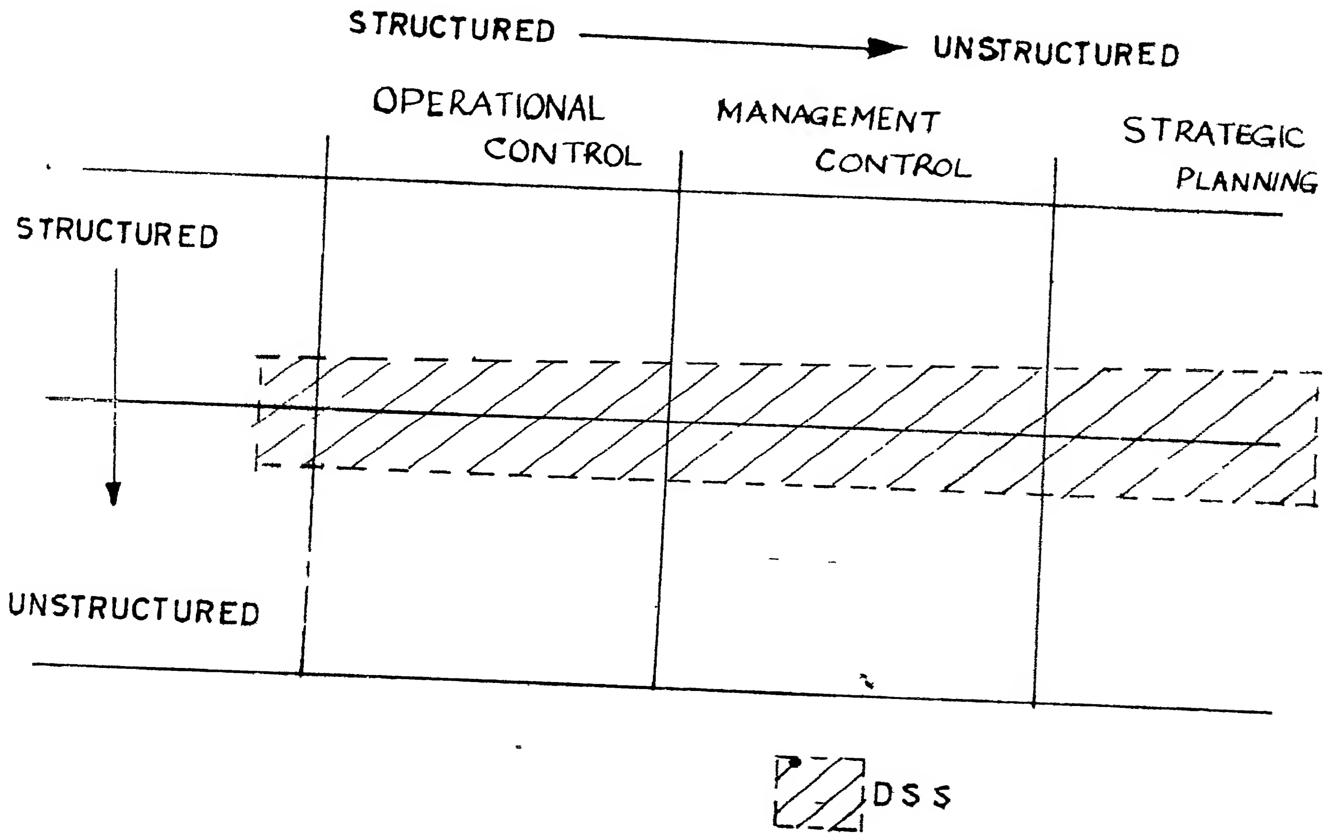
STRUCTURED
UNSTRUCTURED
OPERATIONAL CONTROL
MANAGEMENT CONTROL
STRATEGIC PLANNING
STRUCTURED
UNSTRUCTURED
DSS

FIG 2.1

examine the processes used by humans, who have handled such tasks and try to improve upon them.

There are three categories of managerial activities :

1) Strategic planning
2) Management control and
3) Operational control,

which fall in both structured and unstructured problem types as shown in figure 2.1. In the grey area between the structured and unstructured problems is an important class of problems where the system alone or the manager alone does not make as effective a decision as the two in combination [8]. These man/machine systems are colled ' decision support systems (DSS)'.

The processes of problem solving are the familiar processes of noticing, searching and modifying the search direction on the basis of clues. Problem solving may be viewed as a way of reaching unstructured decisions by reducing them to a series of structured decisions. The DSS are intended exactly for this purpose of arriving at decisions to unstructured problems.

Our growing understanding of unstructured decision making will bring about two quite different kinds of changes in management

i) Prospects for automating certain aspects of the decision making process in the unstructured domain

ii) Giving deep insights into human thought processes, it will provide new opportunities especially through education and training to improve unstructured problem solving abilities.

These requirements of modern business have stimulated the research in the area of DSS to provide support to the decision maker. Another contributing factor is that a designer of DSS need not be an expert decision maker himself.

2.3 CONSIDERATIONS IN BUILDING A DSS:

Components of DSS [8]:

To realize full potential of DSS a set of components must be put together. The first and most important element is the manager who is intimately involved in the decision process. His skill and knowledge of the problem area can not be substituted by any machinery or model,however intricate. The remaining four parts of the system are: models, a computer, a communication device to permit the manager and the computer to work together and a source of raw data upon which the manager and computer can draw when necessary.

Requirements of DSS :

I Information:

The decision maker should be supplied with only relevant information (information can be defined as all material pieces of knowledge which may be used rationally in making a choice among alternatives by a decision maker who has the responsibility and authority to make that choice).

II Model:

A model is a representation of real world systems. Thus the model should submit itself in studying the impact of various factors on the system as a whole. The great advantage of DSS is that the equations do not need to deal with all the factors at the same time and can even omit some of them. When a factor has to be considered , which the model does not have the capacity to handle, the manager can supply his own estimate. Conversely the manager can safely rely on the model to carry out the numerical and analytical parts of the process. The interaction of the manager with the model permits the strengths of the computer model and the strengths of the manager to be brought to bear on the same problem at the same time. The intuitive judgement of the manager, with his years of

experience of the business, cannot be programmed or computerized. Similarly the data storage capacity of the machine and the calculating power of the model using the machine are far beyond the abilities of the manager. Each can contribute to the decision through a DSS.

In building a good DSS, a person with a thoroughknowledge of the practical situation (i.e. the manager) must be involved in designing the system so that important factors are not left to be resolved by oversimplified models. On the other hand a good model designer must also be involved, so that the full benefits of models which can help may be obtained.

How should the models be structured ? :

The models for finding out that there exists a problem are :-

1) Historical- Problem is noticed when there is some descrepency between projected performance based on past and actual performance

2) Planning - Problem is noticed when the actual achievement falls short of targeted (Planned) level

3) Other People's- Problems are brought to the notice of a manager by people from outside that department.

4) Extra - organizational - Problems are cited when the performance of a business entity is compared with another business entity.

As shown in the figure 2.2 once the problems are defined they have to solved by a combination of explicit and implicit models. DSS have helped in externalizing, as much as possible the models implicit to a manager. The decisions are to be arrived at by the compination of descriptive and normative models. Descriptive models explain how things are, where as the normative models otherwise, known as prescriptive models say how the things ought to be. These models have analytical and mathematical models embedded in them.

Some of the desired qualities in a model are

(i) The model should be simple.

(ii) It should be robust- One can not afford to get poor answers.

(iii) Easy to control, to be able to deliver the kinds of outputs the manager is looking for.

(iv) Adaptability to new conditions.

(v) Completness- It should include major variables.

(vi) It must be easy to communicate with.

III Tools for Solving the Problem:

Online, time-sharing computer systems have made it possible to think and act fast because of their contribution to user education.

Cost/ Benefit Analysis:

General studies of decision making have indicated the potential benefits of a computer support for decision making. These potential benefits can be divided into 2 categories - displaced cost and added value. Displaced cost results from reduced costs for data gathering, computation and data presentation in support of decision making. Added value results from investigating more alternatives, doing more sophisticated analysis, making a quicker decision etc. Often it is difficult to identify the added value because it does not occur on a routine basis. Hence it is difficult to quantify the benefits thus accuring although small improvements in decision making can result in large long term benefits.

Choice of Problem area for DSS:

The problem must be of central importance to a manager. In addition, since most of DSS are interactive computer based systems, the following criteria lend

themselves favourably to a DSS

(i) large data base

(ii) high volume of manipulation(of data)

(iii) Analysis in stages and iteratively

(iv) judgement required

(v) complex interrelationships between variables

(vi) communication among people from several disciplines.

CHAPTER III

CORPORATE PLANNING

3.1 NEED FOR CORPORATE PLANNING [10] :

Business organizations have been involved in countless efforts to improve corporate and budgetary planning, organization and control especially in order to cope with and overcome severe declines in economic activity. Generally stated, firms need to anticipate internal and external changes, discover the best alternatives for accomplishing organizational objectives and initiate actions which would enable them and the economy to attain normal economic growth.

The function of corporate planning is to decide what a company's long term objectives are and how to achieve them. Corporate planning takes full account of the company's environment before drawing up plans and lays much emphasis on taking a long look ahead.

Corporate planning has effectively solved these organizational (corporate) problems in planning and control. These models permit management to :

1) et new corporate goals
2) evaluate alternative courses of action

3) analyze the effect of interacting internal and external factors
4) validate conventionally prepared forecass and procedures
5) identify specifically what initiative is required
6) develop a management information system or subsystem
7) reduce response time.

Focus on such models has included the development of appropriate computer based models for individual departments as well as corporation as a whole.

3.2 BENEFITS FROM COMPUTER BASED PLANNING [7]:

Some of the benefits are :

1) Reliability- It reveals the reliability of a predicted set of figures in terms of an error rate or standard error of estimate.
2) Useability- The model is easy to use and the manager can run simulations on the basis of various assumptions for each division.
3) Predictability- The corporate manager is able to observe the reliability of the prediction after using the model for some time. He is consequently able to examine m alternatives than before to identify the factors which

contribute most and evaluate the soundnessof planning.

4) Suggestibility - with adequate analysis and simulation runs the gap between the planned and actual figures of a particular plan will tend to narrow.

5) Quick responsiveness- which enables' continuous' thinking on the part of the manager.

6) Sometimes seemingly impossible taskscan be performed by these models by simulating the creativity of the model builder.

3.3 DESIGN OF CORPORATE PLANNING MODELS:

In broad terms a corporate planning model involves planning in marketing, production and finance. Each of these models may in turn have submodels for specific tasks. For example a production model may have submodels for scheduling, inventory control, costing etc. But all these models need not provide answers to the nearest rupee; rather an answer nearest to a lakh or a crore (of rupees) will be good enough depending upon the size of the business organization.

The general procedure for a corporate plan is as below. The marketing function forcasts the demand for its products for the next 4-5 years based on past data and the environmental factors. After this forecast some of the demands are manipulated to suit the organizational goals. This demand manipulation is done usually for the next year. The demands that are obatined

after this step are called planned demands for the next period. These planned demands are to be met by production function, which has its own resource constraints. In the production model the planning is done at aggregate level without going into more details of production. The required work force size interms of regular, overtime layoff and new hiring labour hours is calculated to meet the demands. Also inventory levels are planned to have minimum inventory carrying costs. Once the production planning is done, the financial analysis of operations at this planned level is carried out in financial models. This includes generation of income statements, balance sheets, financial ratios etc. for the various levels of operations. Finally a satisfactory level of operations is arrived at and that is taken as the plan for the next time period.

Methodologies for Corporate Planning Models:

Some of the methodologies used for corporate planning are discussed by Naylor [11]. They are

a) systems approach
b) system dynamics approach
c) econometric analysis
d) optimization approach.

3.3.1 Systems Approach (or Target Variable Approach):

In this approach the behaviour of the firm can be described by a set of equations in which it assumes that the decision maker has specified a target value for each of the endogenous variables and the equations are solved simultaneously for given values of the exogenous, lagged endogenous and stochastic variables. The problem of balancing the number of equations and the number of decision variables is likely to be a serious limitation of this approach. Setting up a specific target for a particular variable is also questionable. Availability of this information to the analyst is an impossibility; also the approach is not flexible. For example, in the model one has included all the variables which are of considerable importance to the decision maker. Suppose after some time, one wants to insert or delete a few decision variables, which is quite natural in the business system a serious problem of imbalance will result.

3.3.2 System Dynamics Approach:

This is a method of analysing problems in which time is an important factor. The main aim is to find policies which will control the firm effectively in the face o the shocks which will fall upon it from the outside world. Generally system dynamics is good for study of the dynamic behaviour

of the firm, which suggests changes to structure, policies or both, for improvement in the behaviour. To set up a dynamic model for simulating company behaviour,one must adequately describe the real system which it represents. Getting the data will often be difficult. If the company under study produces seasonal items,where day-to-day behaviour of the variables is not our concern, we will be taking atleast one year as period to define the complete cycle of the company performance. So defining rates and levels-essential requirement for system dynamics modelling-will also be a problem.

3.3.3 Econometric Approach and Simulation:

Modeling by econometric approach improves one's knowledge of the market for a particular product or an entire industry, since econometric models provide us with explanatory power. On the other hand the models based on this approach enable us to evaluate the effects of alternative marketing policies on sales valume, sales revenue and market share. We can also evaluate the effects on our markets of alternative assumptions about the national economy as well as alternative policies which may be employed bv our competitors. Econometric models also turn out to be simulation models on which we conduct'what if?' simulation experiments. With simulation one can show the corporate decision maker ,the consequence of the proposed managerial strategy.

3.3.4 Optimization Approach :

This approach proceeds with a specific objective function subjected to a number of constraints and will be desirable where corporate goal is to minimize cost function or maximize profit function. The above objective is true but might not be sufficient for any company. Most companies have multiple objectives, which may not be fixed for long run. For example, for a couple fo periods it may think of maximizing productivity and next of maximize sales revenue, next to maximize market share and so on. Therefore a planning model based on optimization seems to be futile. As an analyst it is very difficult to get the decision maker's preference for the corporate goal. Moreover the constraints are situational and their values are not fixed. This approach also needs perfect knowledge about the nature of cost function, Production function, revenue function and so on, which is hardly elicited from a complex system. However, with multiobjective optimization techniques at hand, we can overcome many of these short comings, though the model needs very good knowledge of the system on the part of the analyst. Moreover these are by and large prescriptive and hence the answers can only be taken as guides in solving the overall model.

3.3.5 Conclusions:

Though the econometric approach has clear advantages over the other approaches in terms of formulation (of problem), understanding the process of planning etc ,it is not used in the current work. The effort in the current work is more on optimization approach. The strengths of econometric models can still be brought to bear on DSSCOP for any product(s), when this is implemented for a particular company/ industry.

CHAPTER IV

DESIGN OF DSSCOP

4.1 SUITABILITY OF A CORPORATE PLANNING PROCESS FOR A DSS:

It is explained in chapter 2 that the strengths of a DSS lie in semistructured decision making tasks. The corporate planning process for a firm as explained in chapter 3 is a very complex process and as such there is no cut- and - dried method of doing it.

Forecasting of demands is done using various techniques- time series analysis, regression, econometric etc-which heavily rely on the past. But a business concern is not lucky enough to rest, armed with only this data. The future is very uncertain and a wrong assumption on the part of a corporate planner (henceforth called as a manager) may land the company in serious trouble. Hence the manager has to resolve various conflicting pictures of future, thus bringing in human element to the system; but there is no escape from it.

Production planning, though, more structured in comparison with demand forecasting, relies on human judgement in deciding about the operating standards in the

framework of existing industrial atmosphere. For example the levels of overtime allowable, loading of machines, new recruitment/ lay-off of labour,inventories etc, call for the discretion of the manager .

Finally the performance of a company is measured in monetary terms, It is here that the health of the business is diagonised. The manager naturally wants to see the impact of various decisions on the profitability of the business . This calls for a quick and reliable system, which supplies him the kind of alternatives, he wants.

The above mentioned semistructured problems in a corporate planning system make it qualify for a decision support system. Moreover the manager at the level of corporate planning is not expected to be a computer professional to do all the model building by himself; even if he is, he cannot possibly afford the time. Thus a DSS in this area is well justified.

4.2 SYSTEM DESIGN:

The strategy for design and development of a DSS is one of evolution over a period of time. DSS deals with semi-structured problems and hence the design and implementation are inseperable and evolutionary. As a result the initial design will, in most cases, prove to be

incomplete. This is all the more true as the decision makers learn more about the problem and the problem solving process through analysis, implemention and usage of DSS. The perception of various situations and problems changes with time and usage. Thus there is no clear break between design and implementation. Similarly there may be no precise end to implementation ; evolution of ideas, the user's ongoing learning and a shifting environment lead to new adjustments and developments.

The DSS designed and implemented in the present exercise is a sort of an initial design. The structure is modular and consists of several small and seperate parts which are linked together. This is to enable ease of extension and modification as the experience grows. This is in keeping with the evolutionary and adaptive approach to designing a DSS as suggested by a number of experts in this field.

4.2.1 Modular Approach [1]:

This system (DSSCOP) is built in modules or DSS generators such that these program units have one entry and one exit . A DSS generator is a building block for DSS that performs one or more data retrieval and/ or calculation operations. Thus the whole system is coded in small procedures which have a definite task to perform. Also the idea is to enable extension of this work or implementation for a real

situation with least difficulty. For example there is a procedure which just reads sales data for all the products into memory addresses.As the DSS are most useful with large data bases the sales data have to come from such databases only . Hence retrieving only sales data without bothering about other data at this juncture helps in implementing the real situations. Similarly the information regarding labour and machine hours, assets, costing etc. are supplied by procedures, which are well seperated from others. The files which store such data are also independent for the same reason.

4.2.2 Decision making phases:

The different phases of decision making-intelligence, design, analysis and review-are supported by providing extensive facilities to see all the input data and information regarding policy parameters. This helps in compiling the relevant information. Various alternatives can be worked out very fast so that a large portion of the problem domain is searched and analysed. Among these alternatives, the manager selects the best course of action to suit his requrements.

4.2.3 Human Intervention:

The success of any DSS depends upon how best the strengths of models and computers are combined with that of the manager to solve semistructured problems. The models

are provided throughout the system which either explain the manager's thinking or prescribe solutions to his problems. The exponential smoothing ,optimization, financial models etc provide quick reflections of manager's thoughts. The manager can safely rely on these models and concentrate more on modifying his assumptions. Thus the manager can exercise his judgement in demand manipulation, exponential smoothing model selection, linear programming problem formulation etc.

4.2.4 Model Structure:

It was stated that an ' optimum ' model structur is very essential for solving any problem. There are many classifications of models such as implicit and explicit models, descriptive and normative models, analytical and mathematical models. The models like exponential smoothing and optimization provide explicit model support to the implicit models of the manager, which are given out in the form of subjective judgements in DSSCOP. The mixture of descriptive and prescriptive (normative) models, are also used carefully. Exponential smoothing and optimization models respectively, can be cited as examples to this classification. Similarly financial and optimization models can be said to represent analytical and mathematical models respectively.

4.2.5 Adaptability of Models:

The models incorporated are simple and easy to use. Sufficient information is provided to the user through help commands and other terminal messages to educate the user about the models. The responses sought from the user are through simple and straight questions with most of the complex problem-solving, done by the models. All the models are intended to be adaptable under varying conditions. In fact the DSSCOP was conceived to be able to solve a general class of problems in corporate planning, faced by a firm, rather than restricting its use to any particular firm/industry. The manager is provided with enough room for manoeuvrability in model selection/ operation over a range of policy variables. The provisions for parameters' selection, constraints addition in optimization model is a case in point. This approach reduces the shortcomings of a DSS due to not-so-thorough knowledge of the model builder about the actual system.

4.2.6 User Education:

The approach to enhance the knowledge of the decision maker is by providing immediate information about the impact of a particular variable among several of them over the entire system. The manager will know the extent and direction of these impacts seperately, which helps him in resolving

the conflicts when all of them occur together. Also he can make a large number of runs which adds to his 'experience' in this area of corporate planning.

4.2.7. User Interface:

The most important aspect in a DSS design is providing good user interface, since most of them are used on on-line terminals. The ' Question/ Answer' (Q/A) interface design tends to be the most successful with inexperienced and infrequent users who are unfamiliar with computer programming. The main disadvantage of a Q/A design is that it leads to awkward usage patterns, if during a dialogue, the user needs to modify answers to previous questions. With Q/A design the DSS asks the user a question, the user answers it and so on until the DSS produces answers needed to support a decision. Normally a Q/A interface would use ' natural' language and may determine the next question based on the answer(s) to the previous question(s).

There is a high probability that a DSS undergoes many modifications including the user interface. Hence the code for user interface should also be in modular form and hence susceptible to alterations.

4.3 CONCLUSION:

The corporate planning function has many unstructured problem-solving tasks in addition to the

structured ones. Thus with many explicit models available for the structured tasks the whole exercise provides a semi-structured decision making problem.

The DSSCOP is designed in modular form, for it be able to lend itself for modifications later on . The essential components- the problem, the manager, the models and the tools for solving the problem- are given due importance to achieve a good DSS. The models are also structured in such a manner as to provide the best possible results. provisions are made for dynamic behaviour and adaptibility of the models. Finally a question/ answer interface design is provided for communication between the manager and the models.

CHAPTER V

DETAILS OF IMPLEMENTATION

In this chapter we discuss the specific implementation details of the system including various sub-programs and their structure and how they are linked together. The basic implementation strategy is as below:

5.1 ELEMENTS OF SYSTEM CODE:

The code for DSS consists of 3 parts as explained below :

1) The main program and most of the procedures are written PASCAL, which supports various decision models and interacts with the user.

2) Some of the subroutines are written in FORTRAN for graphics use. The graphics package used is Interactive Graphics Library (IGL), commercially known as PLOT-10, available on the DEC-1090 system at I.I.T. Kanpur. This package is more powerful than GPGS package.

The reasons for using FORTRAN subroutines instead of PASCAL procedures are:

- that all the IGL routines that are used, need to be declared as external procedures in a PASCAL program, which makes the code undesirably long.
- that some of the FORLIB functions and other utilities which are accessed by FORTRAN calling programs are not accessible to PASCAL Calling programs on DEC-1090.
- that a good and easy-to use interface is available on this installation to call FORTRAN subroutines from a PASCAL program.

3) Interfacing between PASCAL calling programs and FORTRAN subroutines is done using a program called FTNLNK. This should be the first procedure invoked in a PASCAL program.

The command for executing this system (DSSCOP) on DEC 1090 is :

. EX DSS.PAS , GRAP.FOR,SYS: FTNLNK. REL,/ SEA SYS: IGL.REL
<PASCAL Program>,< FORTRAN program>,

5.2 DATA FILES :

As explained in chapter-4, the data and procedures were maintained seperate as far as possible to achieve modular design. Hence there are many files, some of them containing very small number of data. This is to facilitate the supply of data from database in a real implementation of DSSCOP.

These data files are explained briefly in the following paragraphs.

1) INPUT :This file stores sales data of 5 products for the last 10 years. There are 10 records, each containing data about the 5 products for a particular year.

2) COSFIL: This stores data for costing purposes and also price of each product. The first 5 records contain labour and machine hour requirements and direct material costs for each product. The hourly wage rate, salaries, maintenance and power overheads and machinery and building assets are contained in the next records. It may be noted that these data are not so easily available in a real implementation. But the procedures to extract these data from data base can be written seperately and linked to DSSCOP without much difficulty. The last record containe the existing prices charged for all the products.

3) PACFIL : A list of demand determinants are contained in this file, with one determinant in each record excepting the price of the product. The length of this string is limited to 60 characters. Currently there are seven such factors, whose number can grow depending on the type of industry and their relevancy.

4) PROFIL: This file stores data relevant for production planning. The first record contains the cost of holding inventory for each product, while the second record contains the hourly wage rate for overtime, lay-off and new-hiring of labour. The last 5 records contain data about inventory. Each of these records contains the number of days' demand to be held in inventory at the end of next planning period and the number of pieces carried over from the last period, for a particular product.

5) ASSFIL: This file contains data about assets position. It comprises of machinery assets, building assets and current assets data. Some of these data are duplicated here (the reader is reminded of their presence in COSFIL also), which may introduce inconsistancy. But the idea is to get assets from database seperately for working out assets details. Once again, this operation is done probably through a procedure operating on the same database.

The other two files ABSFIL and FACFIL are just text files, provided for helping the user. ABSFIL contains general instructions for using DSSCOP, while FACFIL contains a list of demand determinants, which may be seen by the user before he actually goes through the exercise of their individual impact on damand of a product.

5.3 FLOW DIAGRAM:

The implementation flow diagram of DSSCOP interms of self explanatory procedure names (they are briefly explained in 5.4), is as shown in the figure 5.1. As soon as the DSSCOP starts executing, offer to help the user is provided. This is to enable him to know how the system works and how to control it . It also gives some useful suggestions about entering the user responses during interaction with the user.

DSSCOP works in three subsystems namely,

1) Forecasting
2) Production and
3) Finance,

which are briefly discussed below.

5.3.1 Forecasting Subsystem :

The past sales data is read from a data file, which are used for forecasting. The forecasting model at this stage is single smoothing exponential model with α=C=0.20. The user is given the option of selecting either single smoothing or double smoothing models with different smoothing constants. Computer graphics helps him in selecting these models for each product.

Once the models are selected for forecasting the demands for different products, the exercise of demand manipulation, is taken up. Because the forecasted demands are somewhat given to the company, which will be applicable in the absence of any change in the market conditions or company efforts, whilc,demand manipulation is done to exercise control over the demands of some products due to anticipated changes in market conditions or extra effort on the part of the company [5]. Demand manipulation is done with different criteria in mind, the most important being the profitability. This criterion is implemented in DSSCOP.

The linear programming problem (LPP) is formulated for maximizing profits subject to machine and labour capacity and demands' range constraints. The demand ranges as percentages over the estimated demand are interactively supplied by the user. At this stage the user can specify more constraints, if he has any, in addition to the above mentioned constraints set.

The user will be asked to provide subjective estimates of possible changes in demands as a consequence of price change only. These estimates are used to change the estimated (forecasted) demand levels, with the ranges

remaining the same. At this point the formulation of L.P.P. is complete and hence can be solved. The demands obtained from this solution give an idea of optimal sales-mix.

The user is now asked to consider demand determinants other than price. His estimates of changes of demands for a possible change in a particular determinant are taken. Such data for all the determinants are combined for each product and used for shifting the estimate of the demand from the previous level. This provides another formulation of L.P.P. which is solved again and the results displayed. Now the user is given the option of formulating different L.P.Ps for different impacts of the demand determinants including or excluding price; such L.P.Ps are solved and so on until the user is satisfied with the sales-mix.

5.3.2. Production Subsystem:

When a proper sales-mix is determined using optimization model, they become ' planned demands' for the next period, usualy one year. Now it is the responsibility of production function to meet these demands. Production function will have its own constraints like available regular labour hours, allowable overtime, lay-off and

new-hiring of labour, commensurate with the existing industrial atmosphere and the company's history. Also it has to take care of inventory levels. This problem of production planning is again formulated as on L.P.P with an objective of minimizing costs [2]. The decision variables are the production volume and ending inventory level of each product, required regular, overtime, lay-off and newly-hired labour hours. The constraints for this L.P.P are available labour and machine hours, allowable overloading of machines, minimum closing inventory levels and allowable levels of overtime, lay-off and new hiring of labour. This L.P.P solves the production planning problem and provides the optimum values for the above mentioned decision variables. The production planning problem can be solved many times for varying parameters in the L.P.P formulation and hence to arrive at an agreeable production plan.

5.3.3 Finance Subsystem:

Financial analysis of the above production plan is done in the next subsystem. First of all a profit/loss account is provided for each product in the form of a table. This is followed by different financial ratios for critical review of profitability of the business. Now the manager will be in a better position to decide the level of

operations. At the end of financial ratios a graphic display of sales-costs combinations for different returns on investment (ROI) is provided. This helps the manager to know the changes in sales/ costs that one needed for a targetted level of ROI.

Once the financial analysis is over, the manager is given the option of going through the whole exercise of demand manipulation, production planning and financial analysis once again. Any number of such iterations are carried out till the manager is satisfied with the results .

Thus a corporate planning manager can quickly work out various alternatives, analyse them and select the best among them. Since a large number of runs are possible the manager can learn from his own assumptions and mistakes. This will definitely result in improved decisions.

5.4 LIST OF SUBPROGRAMS AND THEIR FUNCTIONS:

Following is a list of actual subprograms and a brief explanation about their functions.

5.4.1 PASCAL Subprograms:

1) ABSTRACT : This procedure provides help to the user in running DSSCOP. The help information is

stored in ABSFIL, which is read and written on TTY by this procedure.

2) PASTSALES: This procedure reads the sales data of last 10 years for the 5 products from file INPUT. Though, this is a trivial function it is maintained seperate for the reasons outlined earlier.

3) FORECAST: Here time-series forecasting for all the 5 products is done using single smoothing exponential model with α = C=0.20 .

This model is stated below [15]

$$F_t = \alpha D_t + (1-\alpha)*(F_{t-1} + T_{t-1})$$

$$T_t = C (F_t-F_{t-1}) + (1-C) T_{t-1}$$

$$F^*_{t,\eta} = F_t + \eta T_t$$

where ,

D_t = actual demand for time period t

F_t, F_{t-1} =forecast estimates at the end of time periods t and t-1 respectively

T_t, T_{t-1} = trend estimates at the end of time periods t and t-1 respectively

$F^*_{t,\eta}$ =forecast for a period, which is η periods ahead, done at the end of time period t

α, C =smoothing constants.

Exponential smoothing models give a higher weightage to the more recent demands, thus reacting more quickly to the changing levels of demand. These weights are given by assigning values between 0 and 1 to α and C.

The input to this procedure is past sales data, while the outputs are projected demands for the next year and the forecast estimates at different time periods.

4) MODELFIT : This procedure interacts with the user and helps him in model selection for forecasting by calling FORTRAN routines, which in turn call IGL routines. The selection of exponential smoothing model can be done for any number of products seperately.

5) PRICECOST: Here the casting is done using the production data from data files. The costing procedure is briefly outlined below.

(a) $$SAL(i) = \left(LHR(i) / \sum_{i=1}^{N} LHR(i) \right) * (1.05 * OHSAL/DEM(i))$$

(b) $$MNT(i) = \left(MHR(i) / \sum_{i=1}^{N} MHR(i) \right) * (1.05 * OHMNT/DEM(i))$$

(c) $$PWR(i) = \left(MHR(i) / \sum_{i=1}^{N} MHR(i) \right) * (1.05 * OHPWR/DEM(i))$$

(d) $$MCDEP(i) = \left(MHR(i) / \sum_{i=1}^{N} MHR(i) \right) * (0.10 * MA/DEM(i))$$

(e) $BLDEP(i) = (0.05 * BA) / \sum_{i=1}^{N} DEM(i)$

(f) $COST(i) = CLR*LHR(i) + DCMATL(i) + a + b + c + d + e$

where

COST(i) = cost of manufacturing (and selling) a unit of product i, i=1,.... N

CLR = cost of a regular labour hour

LHR(i), MHR(i) = labour and machine hours respectively consumed by a product i

DCMATL(i) = direct material cost for product i

SAL(i), MNT(i), PWR(i) = salaries, maintenance and power overheads respectively allocated to each unit of product i

MCDEP(i), BLDEP(i) = machinery and building depreciation respectively allocated to each unit of product i

DEM(i) = demand (forecasted) for product .i .

The allocation of overhead costs is done based on the labour and machine hours consumption of each product. Salary overheads are allocated proportional to the labour hour requirements of a product, with the assumption that

cost of supervision, general administration etc. are directly proportional to work force size. Maintenance overheads and power charges are allocated proportional to the machine hour requirements of a product. This is based on the assumption that these costs are directly incurred by the machines. It should be noted that an allowance of 5% increase in these overheads is allowed for the next year to take care of general increase in these costs over the current values. However this can be modified during production planning.

Depreciation on machinery assets is again allocated to each product based on its machine hour consumption. This is straight line depreciation applied over a period of 10 years with no scrap value for the machines. Depreciation on building assets is allocated equally among all the units of products. The depreciation period is 20 years with no scrap value.

The values for LHR(i),MHR(i) etc. are read from data files in DSSCOP. These figures may be very erroneous in a real implementation, for, there will be different skills among labour, while machines have varying sophistication. Nevertheless the current figures may be taken as ' equivalent ' values of LHR(i), MHR(i) etc.

This procedure gives the projected costs/unit for each product, for the next planning period (year), which are used for further calculations in DSSCOP. The procedure also supplies the existing prices of all the products by reading from data files.

6) MCLABCAP: This procedure supplies the values of available labour hours, total labour and machine capacities. They are worked out as below.

current labour-hours = 0.95(No. of workers * 45 * 52)

full capacity labour hours= 0.95(Full workers *45*52)

full capacity machine hours =0.80 (No. of machines *45*52)

The assumptions in working out these figures are :

i) there are currently 125 workers, but the company has a labour capacity of 150 and worker utility of 0.95

ii) there are 50 machines with machine utility of 0.80 and

iii) the normal shift hours are a total of 45 in each week.

These figures may be very incoherent, but it will suffice for our current exercise. The independence of this procedure helps in supplying the actual figures in a real implementation.

7) PROFITLPFORM: This procedure does the initial formulation of L.P.P for optimizing sales-mix. The formulation of L.P.P is as below.

$$\text{MAX Profits} = \sum_{i=1}^{N} C_i X_i$$

or

$$\text{MIN} -(\text{Profits}) = \sum_{i=1}^{N} - C_i X_i$$

s.t

$$\sum_{i=1}^{N} \text{LHR}(i) \leq 1.3\ (\text{LABCAP})$$

$$\sum_{i=1}^{N} \text{MHR}(i) \leq 1.3.(\text{MCCAP})$$

$$X_i \leq 1.05\ (\text{DEM}(i)),\ i=1,\ldots.N$$

$$X_i \geq 0.98\ (\text{DEM}(i)),\ i=1,\ldots.N$$

$$X_i \geq 0$$

K= no. of decision variables (including slack and surplus) = 3N +2.

L= no. of constraints = 2N+2

where,

X_i= no. of units of product i, i = 1, ...N

C_i= contribution/ unit of product i

= price(i)-cost(i)

LHR(i),MHR(i)	=	labour and machine hour requirements respectively,of product i
LABCAP,MCCAP	=	existing labour and machine hours
DEM(i)	=	forecasted demand for product i.

At this stage 30% overloading on both labour and machines is allowed. The lower limit of 2% and an upper limit of 5% from the estimated level are imposed on the demands. These ranges may be varied later. The inequality constraints shown above are explicitly converted to equality constraints using slack and surplus variables, as the PSIMPLEX procedure to solve L.P.P requires them to be in that format.

8) RANGEDEM: This procedure fixes the percentages for upper and lower limits on the estimated demand level for different products. These values are obtained interactively from the user by informing him about the current percentages. These percentages are used in formulating the L.P.P. Demands for some products can be fixed at some particular level by giving 0% as both upper and lower limits from the estimated level. This is helpful for some special type of products, made to order, where the quantity is fixed and inventory is not necessary.

9) CONSTRAINTAD: Here the user can add more constraints, if he has any, to those already formulated in

PROFITLPFORM, thus updating the constraint set. The facility of adding a constraint interactively, is provided only to sales-mix optimization, since the decision variables' set does not change. Whereas in production planning optimization this facility is not available, as it is more complicated. However it can be done by modifying the procedure PRODFORM (explained later).

10) PRICEFFECT: This procedure collects the user's judgement regarding demand-price relationships. A non-linear relationship exists between demand and price of a product, which is the famous ' demand curve' in economics. Fitting this curve is a tedious exercise, which is again an approximation only. More over it needs lots of past data. So it is better to invoke the models implicit to a manager to get this relationship. This is an unstructured problem-solving task which relies heavily on manager's intuition.

The manager is asked whether he contemplates any price change for a particular product in the next year. If he does, his 'guess' about a possible change in demand due to this change is solicited. This information is obtained for all the products and the L.P.P to find out optimum sales-mix, is updated by shifting the estimated demand level in the range constaints.

11) PSIMPLEX [9]: This procedure is for solving an L.P.P based on Revised Simplex Method. The input to this procedure should be in the form

$$\begin{aligned} \text{Min} \quad & Z = CX \\ \text{s.t} \quad & AX = B \\ & X \geq 0 \end{aligned}$$

where C,A,B and X have standard meanings.

The same procedure is used for getting optimum sales-mix as well as production planning. In the sales-mix problem the objective function is minimizing the negative profits, while in production planning it is minimizing production costs. The procedure is of a general type, where the decision variables and constraints can be any number. Currently the procedure can handle 30 variables and 24 constraints. This facility can be enhanced by suitably altering the array dimensions in the code.

The outputs from this procedure are the solutions X and Z. It can also detect infeasibility/ unboundedness of an L.P.P.

12) LPRESULT : It presents the L.P. solutions along with forecasted demands. The figures of forecasted as well as planned (L.P solution) demands are provided side by side, so that the user can discriminate between the two

figures. Also the change in planned demands are presented as percentages over the last year's sales, which help the user to know the position of currently planned demands to the previous year's sales.

13) FACTLIST: It reads text from FACFIL and writes it on TTY. The FACFIL contains a list of demand determinants excepting the price of the product. The number of these determinants can vary with the improved knowledge about the market conditions.

Some of these determinants are :

a) Advertisement effort
b) Sales and service force size/quality
c) Product quality
d) Personal income of consumers
e) National economy
f) Global economy
g) Entry /exit of competitors in the market and
h) Government regulations.

14) MODIFYDEM: This procedure again takes care of an unstructured portion in demand manipulation task. The impact of price on demand of a product was considered in the procedure PRICEFECT. Similar exercise is undertaken here for the other determinants listed above. The possible

demand changes for anticipated changes in the above factors, one at a time, are solicited from the user. This is done over all the products. The demand ranges in sales-mix L.P.P are updated in the same way as was done in the procedure PRICEFECT. This gives a different L.P.P formulation which will be solved by PSIMPLEX.

15) ECOFACTORS: It is used to display the demand determinants one by one for getting the manager's judgement on demand changes due to this determinant, by packing them in an array. These factors are only a string of characters, which need not be manipulated and hence computer memory is used more economically by packing them in an array.

16) PRODFORM [2]: This procedure formulates the L.P.P. for production planning. The objective function is to minimize production and inventory holding costs.

The formulation of L.P.P. is as below.

$$\text{Min} \quad COSTS = \sum_{i=1}^{N} CP(i)\, X_i + \sum_{i=1}^{N} CI(i)\, I_i + CLR*R + CLO*O + CLL*L + CLH*H$$

$$\text{s.t} \quad \sum_{i=1}^{N} LHR(i)\, X_i = R+O+H$$

$$R+L = LABCAP$$

$$I_i = (I_{prev})_i + X_i - DEM(i), \quad i = 1, \ldots N$$

$$I_i \geq ND(i) * DEM(i)/365 \quad i = 1, \ldots N$$

$$O \leq M$$

$$L \leq M$$

$$H \leq M$$

$$\sum_{i=1}^{N} MHR(i)\, X_i \leq 1.6\ (MCCAP)$$

$$X_i,\ I_i,\ R, O, L, H \geq 0$$

where

CP(i), CI(i) = cost of production excluding labour and cost of holding inventory respectively for each unit of product i

CLR, CLO, CLL, CLH = cost of labour hour for regular, overtime, lay - off and newly-hired production respectively

production re

R, O, L, H = regular, overtime, laid-off and newly hired production hours respectively

X_i, I_i = production volume and inventory level at the end of the planning period, respectively, for product i

$(I_{prev})_i$ = inventory of product i carried over from last (current) period.

LHR(i), MHR(i) = equivalent labour and machine hours requirements respectively for product i

DEM(i) = Volume of planned demand for product i

ND(i) = inventory policy as the min. no. of days' demand to be held in inventory at the end of next period for product i

LABCAP, MCCAP = total labour hours and machine hours currently available in regular production

M = A large number as upperlimit on O, L and H .

Thus there are 23 decision variables (including slack and surplus) and 16 constraints in this L.P.P. Initially the value of M is put arbitrarily at 70000 hours, while that for ND(i) is 15 days' demand each. Also 60% overloading of machines (i.e. in additional shifts) is allowed to facilitat optimization. These values can be changed interactively at a later stage, according to the requirements of the manager. If there are any more constraints and variables to be included in this L.P.P , it can be done by suitably modifying this procedure.

17) MODIFYPROD: This procedure helps the manager in modifying the L.P model for production planning by changing various parameters, in interactive mode. The current values of these are displayed and the new values solicited, if any. Thus the following changes may be effected.

- PRODUCTION COSTS: There may be changes in these costs due to some cost reduction techniques, technological breakthroughs, sudden hike in some costs etc.
- INVENTORY HOLDING COSTS: The current values are supplied from data base. There may be changes in them in the next year.
- INVENTORY POLICY: To start with, 15 days of demand is held as inventory for all products. This policy can be changed by the manager by intuition or based on some other sophisticated inventory model outcome.
- LABOUR COSTS: They are also likely to change in all categories-regular, overtime etc. -depending upon pending wage revisions or other labour policies.

- LIMITS ON OVERTIME, LAY-OFF AND NEW-HIRING: Any company will definitely have some limits on these labour hours. These are supplied by the manager according to his judgement.
- MACHINE OVER-LOADING : In the L.P.P formulation the overloading was tentatively fixed at 60% . But the manager is free to impose new limits.

This procedure also helps in making the L.P.P feasible, which, if originally infeasible, by suitably modifying the parameters. The best way to check infeasibility is by allowing higher limits on O, L, H and machine overloading or reducing the inventory.

18) PRODRESULT : This reports the results of L.P.P of production planning. The values of production volumes, inventories, required regular, overtime, lay-off and new-hiring of labour in hours are displayed.

The capacity utilizatior figures for this production plan are calculated as below:

Capacity utilization (%) of

$$\text{Labour} = (R+O+H-L)*\ 100/\text{Full labour capacity}$$

$$\text{Machines} = \sum_{i=1}^{N} MHR(i)\ X_i / MCCAP$$

where the symbols have the same representation as before. These percentages for capacity utilization help the manager in understanding the consequences of his production planning strategies in a better way. Armed with this information he can do the production planning in a way more suitable to him in the next iteration and so on until he gets a satisfactory production plan.

19) PLACCOUNT : This procedure produces a financial report of the activities that are planned for the next period. It is an income statement generated for each product seperately and presented together for all products. This helps in comparing the financial outcome due to each product with that of others. The items found in this report are the standard ones which are found in any income statement [17].

At the end of income statement the figures of contribution / unit of each product for each labour-hour and machine-hour are presented. These are intended to give an indepth understanding to the manager about the relative profit of the products.

20) ASSETS: It does the trivial function of reading assets data from data files and transfering them to the main program. This is maintained as a seperate procedure to enable ease of implementation on a real data base as outlined

earlier in the chapter.

21) FINRATIOS : Currently this procedure supplies only two financial ratios namely return on investment (ROI) and finished goods to sales ratio. This number can be enhanced to include all the standard financial ratios, which become meaningful when a full fledged finance system is implemented in a real situation. For, these ratios are clearly defined and it is only a matter of coding them.

The two ratios are implemented to demostrate their purpose in such a system. They are calculated as below:

ROI(%) = (Total net profit/ Total assets)* 100

Finished goods to sales ratio = inventory assets/Total revenue.

22) MODIFYROI: This procedure invokes the FORTRAN subroutine RGRAP to show sales-costs combinations for different values of ROI in graphical form, helping the manager to initiate the thought process to improve the ROI or to operate at different levels at the same ROI.

5.4.2 FORTRAN Subprograms:

The FORTRAN subroutines are called from the main PASCAL program for 2 specific purposes :

a) to select exponential smoothing model and

b) to draw sales-costs combination lines for different ROI.

a) For selecting exponential smoothing model :

These subroutines draw the curves (piecewise linear, as shown in appendix) for the following :

1) Actual sales in last 10 years
2) Single smoothing exponential model and
3) Double smoothing exponential model.

For each product these graphs can be drawn repeatedly for different values of α and C until the user selects suitable model for that product. The model selection is done product by product and hence there is no need to select a common model suitable to all products.

Single smoothing and double smoothing exponential models are supplied by SSMOT and DSMOT subroutines respectively. SSMOT is a duplication of the procedure FORECAST explained earlier, while the DSMOT model is explained below :

Double smoothing exponential model [15]:

$$F_t = D_t + (1-\alpha)^{2} * e_t$$

$$T_t = T_{t-1} - C^{2} * e_t$$

$$e_t = F^*_{t-1,1} - D_t$$

$$F^*_{t-1,\eta} = F_{t-1} + \eta\, T_{t-1}$$

where ,

D_t = actual demand for time period t

F_t, F_{t-1} = forecast estimates at the end of time periods t and t-1 respectively

T_t, T_{t-1} = trend estimates at the end of time periods t and t-1 respectively

e_t = forecast error at the end of time period t

$F_{t-1,\eta}$ = forecast made η periods into future at the end of time period t-1

C, α = smoothing constants for trend and forecast respectively.

b) Subroutines to draw ROI lines:

These routines draw different operating lines for different ROI in a 4- quadrant graph (shown in example session). The X and Y coordinates are percentages of costs and sales increase/ decrease respectively over the current figures. The current figures are the figures given in the income statement.

The operating lines are drawn through the points obtained from the following method.

$$ROI = \text{net profit}/\ \text{Total Assets (TA)}$$

$$= (\ \text{Sales} - \text{Costs})*\ (100 - \text{Tax}\ )/\ \text{TA}$$

i.e. sales = (ROI * TA) / (100-Tax) + Costs

or

$$S = (ROI * TA)/ (100-Tax) +C$$

Coordinates :

$$X = \frac{C- \text{current costs}}{\text{current costs}} * 100$$

$$Y = \frac{S- \text{current sales}}{\text{current sales}} * 100$$

For each ROI, two points are obtained by varying C and calculating S and hence (X,Y). The line passing through these two points represents the operating line for that ROI. By varying the value of ROI,different operating lines are obtained.

It can be seen that the operating line for current ROI passes through the origin, while for others it is either above or below, depending on whether the ROI is greater or less than the current ROI.

The graph for ROI can be read as explained below:

If the company's cost of goods sold changes by X% and that of sale by Y% then the ROI will

a) increase, if the point (X,Y) lies above the current ROI line

b) decrease, if (X,Y) is below this line

c) not change, if (X,Y) lies on this line.

These operating lines help the manager in initiating a suitable strategy to achieve the targetted ROI.

CHAPTER -VI

CONCLUSIONS

In the present exercise undertaken for developing a decision support system to support a manager in corporate planning, a general framework of DSS is designed and implemented on DEC-1090 computer at I.I.T. Kanpur. The thrust has been more on illustrating the application of a DSS than on developing professional package for corporate planning.

The DSS provides support to the decision maker rather than replacing him in making decisions. They are well suited for semi-structured problems where a computer or a decision maker alone cannot make as good a decision as both in unison [8]. Thus the computing power and storage capacity of computers and the long years of experience of a manager are combined to the best advantage in a DSS.

There has been a lot of research going on in this area of supporting decisions. The manager of future will be more involved in computers than today and hence the need for supporting him will be greater [13]. So the DSS have come to stay as one of the distinct research areas as other respectable areas like MS/ OR and DBMS [4].

Corporate planning is an activity done at the top management level in an organization, which has both structured as well as unstructured problems to solve. The future being very uncertain, the manager wants as many alternatives as possible to choose from, which makes the corporate planning a suitable problem for a DSS.

DSSCOP is designed in modular form, so that future extensions or modifications are done easily. It has provision for human intervention and model adaptibility. The modules or DSS generators, which are well seperated from one another, have specific functions to perform. If in future sophisticated models become available for these functions, they can be substituted in place of these modules. For example, if a good econometric model to forecast demand for a product becomes available, the process of manager's supplying his intuitive estimates about demands can be done away with. The models are structured to get the best possible solutions. User interface is very important in any DSS, which in fact decides the success or failure of a DSS in most cases. A question/answer mode of interface is incorporated in DSSCOP.

Since the intention was to develop a DSS frame work, only fictitious data is used from data files. These data files are maintained seperately keeping in view the modular design

and also to facilitate real implementation of DSSCOP.

Graphics facility enhances the human understanding of the problem by presenting the results in a quickly graspable and more discriminative manner. Interactive Graphics Library (IGL) package is used in DSSCOP as it is more powerful than the other available package- GPGS-on DEC-10 at I.I.T., Kanpur.

The present exercise provides only a basic framework of the corporate planning activity. Hence a lot of additional facilities can be developed around this framework. The model is intended to suit most of the industries, and hence additional facilities specific to an industry/company can be incorporated to enhance the power of DSSCOP. Better understanding of the system with more experience should make this system adaptible to changing conditions of industry.

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```
.EX DSS,GRAP,SYS:FTNLNK.REL,/SEA SYS:IGL.REL

[LNKXCT.DSS execution]

              W E L C O M E

                   TO

      THE CORPORATE PLANNING SYSTEM

This system works in 3 subsystems-namely,forecasting
  production and finance
  FOR MORE INFO. ABOUT THE WORKING OF THE MODEL
  TYPE "H" OR "C" TO CARRY ON
>C
  Please note that the sales data are in file INPUT
  Forecasting will be done based on last 10 years data
  using single smoothing exponential model with ALFA=C= 0.20
  Forecasted demands(FOR PRODUCTS 1-5) are:
    5756.    4874.    3762.    3354.    2149.
```

You can fit the exponential model(single or double smoothing)

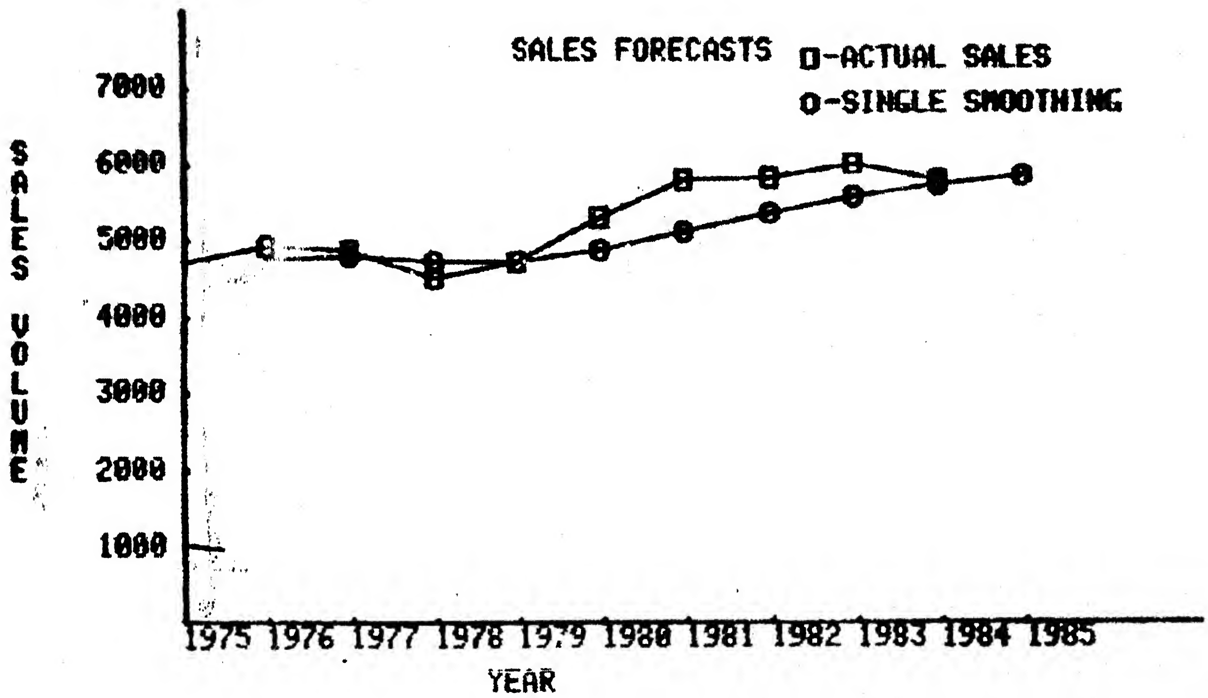
trying different ALFAs and Cs,with the help of GRAPHICS

Do you want to try it for any product(s)?(Y/N)

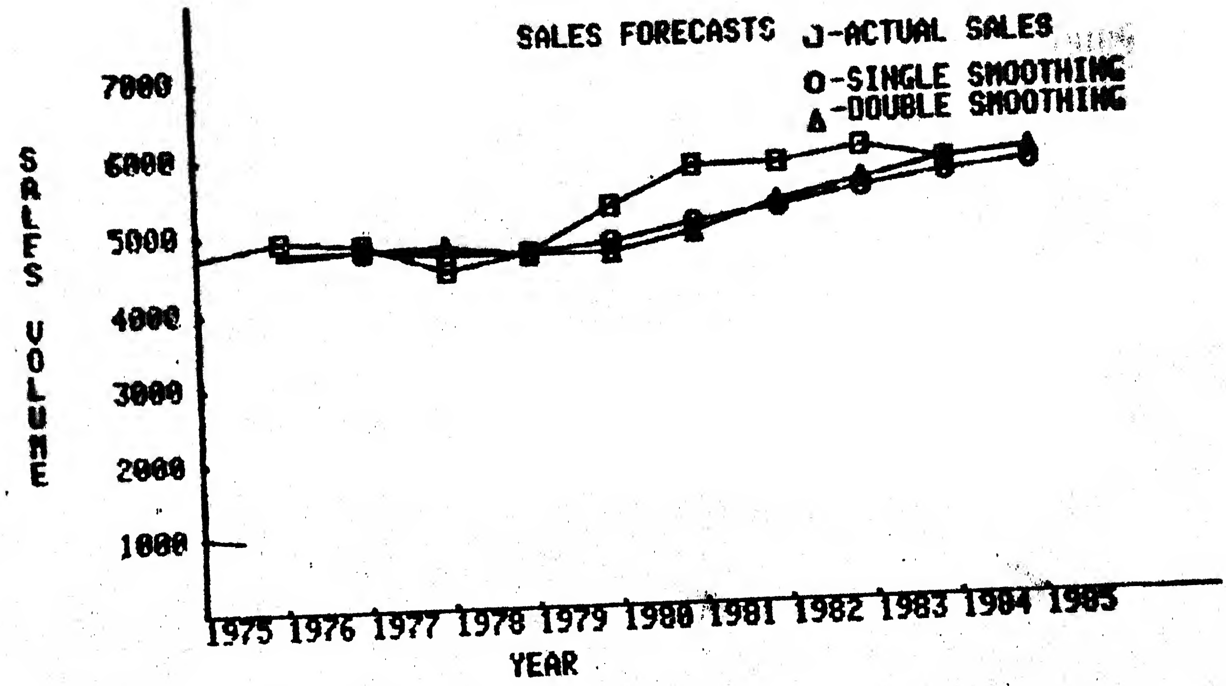
>Y

ENTER THE PRODUCT NO

(i)?1



WANT TO TRY DOUBLE SMOOTHING?(1.FOR YES/2.FOR NO)
?1



THE FORECASTING MODEL FOR THIS PRODUCT IS EXPONENTIAL

SMOOTHING WITH ALPHA= .20C= .20AND

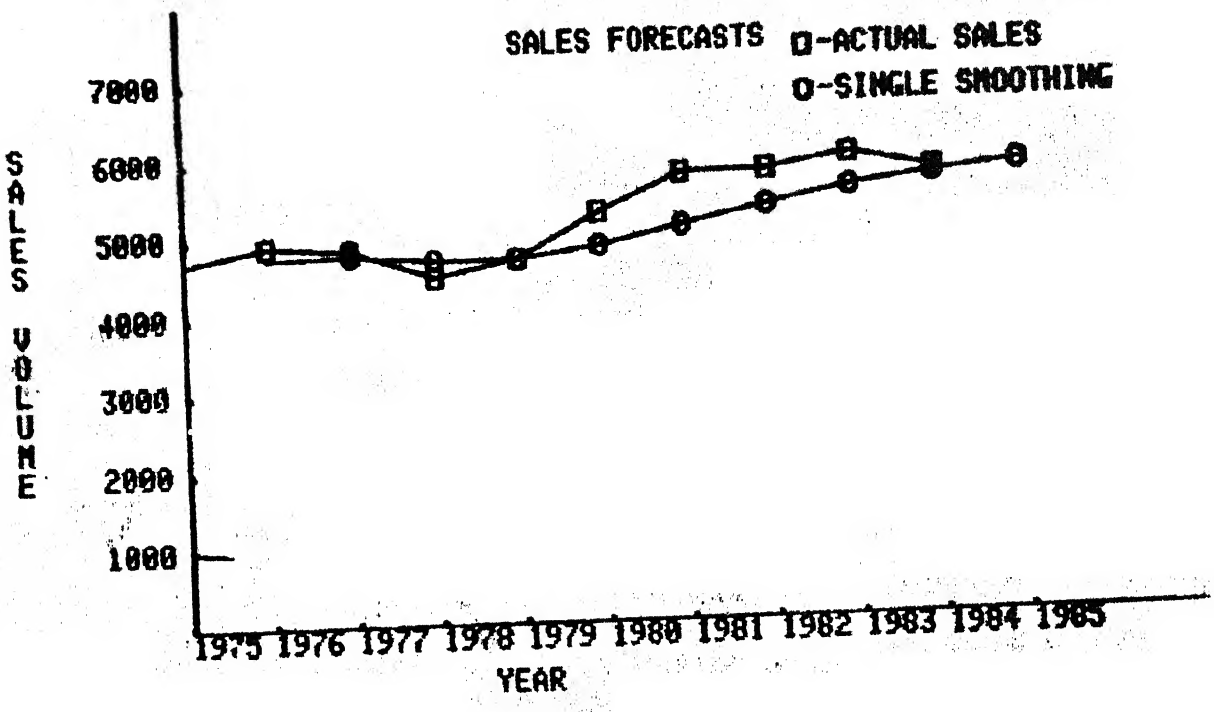
DOUBLE SMOOTHING

IS IT ACCEPTIBLE?(1.FOR Y/2.FOR N):

2

ENTER VALUES FOR alpha AND c

0.25 0.18



WANT TO TRY DOUBLE SMOOTHING?(1.FOR YES/2.FOR NO)
?2

THE FORECASTING MODEL FOR THIS PRODUCT IS EXPONENTIAL

SMOOTHING WITH ALPHA= .25C= .18AND

SINGLE SMOOTHING

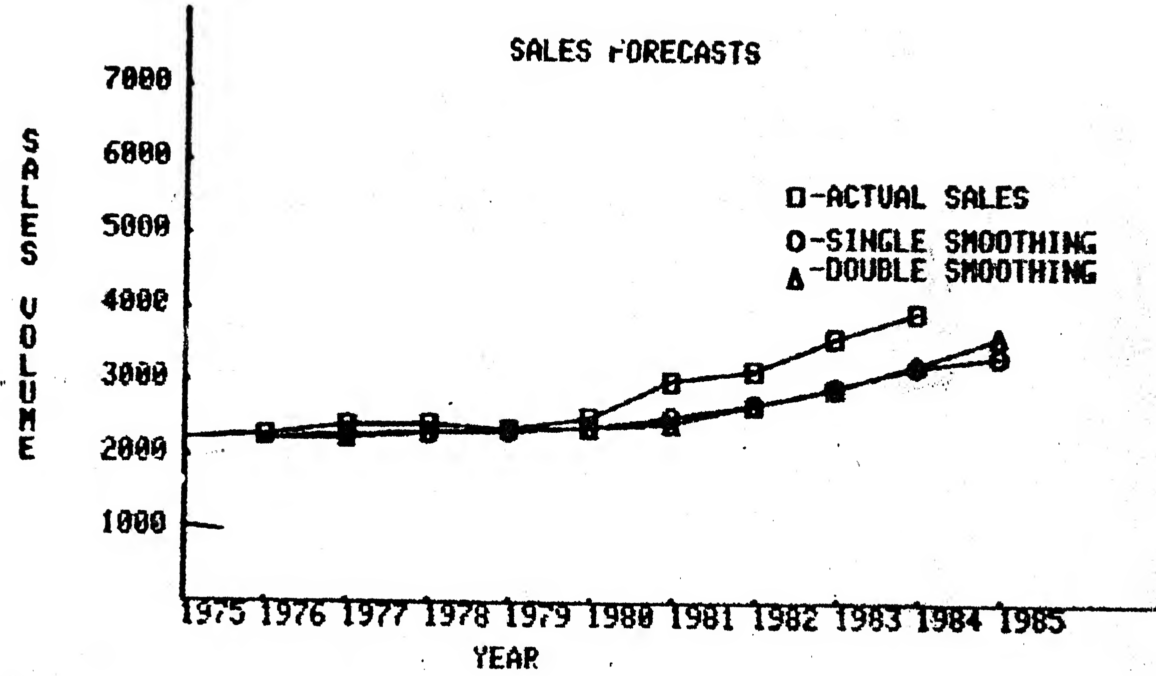
IS IT ACCEPTIBLE?(1.FOR Y/2.FOR N):

1

FORECAST FOR PRODUCT 1 IS 5851. UNITS Any other product?(Y/N)

ENTER THE PRODUCT NO

(i)?4



THE FORECASTING MODEL FOR THIS PRODUCT IS EXPONENTIAL

SMOOTHING WITH ALPHA= .20C= .20AND

DOUBLE SMOOTHING

IS IT ACCEPTIBLE?(1.FOR Y/2.FOR N):

FORECAST FOR PRODUCT 4 IS 3616. UNITS Any other product?(Y/N)

?N

The following are the forecasted demands for products 1 through

5850. 3874. 3762. 3616. 2149.

You can manipulate these demands using optimization

This optimizat [illegible] finding out the optimum sales-mix,

with the sole aim of maximizing profits

subject to capacity(labour & m/c hrs) as well as demand

range for each product, as constraints.So if you have any

more constraints, please indicate their number else type 0

(i)?0

The foll. ranges provide you an opportunity to fix the MIN

and MAX demands, to facilitate optimization of sales-mix

THE RANGE OF DEMAND FOR PRODUCT 1 IS 5733. TO 6143.

i.e a LOW LIMIT of 2.% and a HIGH LIMIT of 5.%

over the average demand.WANT TO MODIFY THEM(Y/N)

>N

THE RANGE OF DEMAND FOR PRODUCT 2 IS 4776. TO 5118.

i.e a LOW LIMIT of 2.% and a HIGH LIMIT of 5.%

over the average demand.WANT TO MODIFY THEM(Y/N)

>Y

type them in REAL form in the same order

(r)?1.0 3.0

THE RANGE OF DEMAND FOR PRODUCT 3 IS 3687. TO 3951.

i.e a LOW LIMIT of 2.% and a HIGH LIMIT of 5.%

over the average demand.WANT TO MODIFY THEM(Y/N)

>N

THE RANGE OF DEMAND FOR PRODUCT 4 IS 3544. TO 379..

i.e a LOW LIMIT of 2.% and a HIGH LIMIT of 5.%

over the average demand.WANT TO MODIFY TH..(Y/N)

>N

THE RANGE OF DEMAND FOR PRODUCT 5 IS 2106. TO 2256.

i.e a LOW LIMIT of 2.% and a HIGH LIMIT of 5.%

over the average demand.WANT TO MODIFY THEM(Y/N)

>N

you can get optimum product-mix for different price

combinations.C..sider only the effect of price change

for the time being

the current price of product 1 is Rs 200.00

Do you want to change the price of this product?(Y/N)

>Y

by what % ?

(r)?10.0

what % change in demand is expected due to this change?

(r)?-4.0

the current price of product 2 is Rs 290.00

Do you want to change the price of this product?(Y/N)

>N

```
the current price of product  3 is Rs  6[illegible].00
Do you want to change the price of this product?(Y/N)
>N
the current price of product  4 is Rs  390.00
Do you want to change the price of this product?(Y/N)
>N
the current price of product  5 is Rs 1450.00
Do you want to change the price of this product?(Y/N)
>Y
 by what % ?
(r)?3.0
 what % change in demand is expected due to this change?
(r)?0.0
 DEMANDS FOR NEXT YEAR FOR PRODUCTS(1-5)
                     1       2       3       4       5
        FORECASTED:  5850.   4874.   3762.   3616.   2149.
           PLANNED:  5525.   5020.   3951.   3797.   2256.
 THE GROSS PROFIT = Rs2005585.34
 % CHANGE OF DEMAND
   OVER LAST YEAR'S:  -4.72   -7.02   -4.79   -3.86   -9.77
 Do you want to try a different price combination?(Y/N)
>N
```

Now consider demand manipulation due to an anticipated change in other factors.Express your Judgement with respect to that factor alone

If you want to have a look at these factors,type T else type C

>C

want to go through this exercise for product 1?(Y/N)

>N

want to go through this exercise for product 2?(Y/N)

>Y

By what % does the demand change for the possible change in:

ADVERTISEMENT EFFORT

(r)?4.0

SALES & SERVICE FORCE SIZE/QUALITY

(r)?1.0

PRODUCT QUALITY

(r)?0.0

PERSONAL INCOME OF CONSUMERS

(r)?0.0

NATIONAL/GLOBAL ECONOMY

(r)?0.0

GOVT. POLICIES

(r)?0.0

ENTRY/EXIT OF COMPETITORS

(r)?0.0

```
 want to go through this exercise for product  3?(Y/N)
>N
 want to go through this exercise for product  4?(Y/N)
>N
 want to go through this exercise for product  5?(Y/N)
>N
 DEMANDS FOR NEXT YEAR FOR PRODUCTS(1-5)
                          1       2       3       4       5
        FORECASTED:    5850.   4874.   3762.   3616.   2149.
           PLANNED:    5499.   5264.   3899.   3797.   2256.
 THE GROSS PROFIT = Rs2015637.42
 % CHANGE OF DEMAND
   OVER LAST YEAR"S:   -5.18   -2.51   -6.04   -3.86   -9.72
 Do you want to do another iteration of demand manipulation?
    ENTER   P..to do price effect also
            D..non-price factors only
            C..to continue
>C
```

Now I will do aggregate planning with the just manipulated demands and other data from data base as inputs.

It is an L.P formulation to minimize cost of production considering capacity,inventory,overtime,lay-off and new hiring

THE PRODUCTION VOLUMES FOR THE NEXT PERIOD(YEAR) ARE:

PRODUCT 1= 5455.

PRODUCT 2= 5290.

PRODUCT 3= 3979.

PRODUCT 4= 3788.

PRODUCT 5= 2309.

INVENTORIES AT THE END OF NEXT PERIOD ARE:

PRODUCT 1= 226.

PRODUCT 2= 216.

PRODUCT 3= 160.

PRODUCT 4= 156.

PRODUCT 5= 92.

REQD. REGULAR LABOUR-HOURS: 263589.7

REQD. OVERTIME-HOURS: 0.0

NO OF LAY-OFF HOURS: 14285.2

NO OF NEW LABOR-HRS HIRED: 0.0

TOTAL COST OF PROD.& INV. HOLDING = Rs 8265125.39

CAPACITY UTILIZATION(PERCENTAGE):

LABOUR 74.76

MACHINE130.78

You can directly go to FINANCIAL ANALYSIS from here.

In case you want to modify some of the coefficients

in the L.P formulation ,you can try.press Y to try else press N

>Y

THE FOLLOWING ARE THE COSTS/UNIT(EXCLUDING LABOUR)

PRODUCT 1 =Rs 186.76

PRODUCT 2 =Rs 178.55

PRODUCT 3 =Rs 496.27

PRODUCT 4 =Rs 220.66

PRODUCT 5 =Rs 1144.00

If you want to modify any of them type Y, type N otherwise

These changes may be warranted with the advent of new

technology or due to change in overhead costs(5% is already added to

>N

What about inventory holding costs?

THE FOLL. ARE THE CURRENT INV. HOLDING COSTS/UNIT

PRODUCT 1=Rs 17.00

PRODUCT 2=Rs 19.50

PRODUCT 3=Rs 65.00

PRODUCT 4=Rs 30.00

PRODUCT 5=Rs 103.00

type Y to alter; N otherwise

>N

```
  What about cost/labour-hr of regular,overtime,lay-off & hiring?
  THE FOLL. ARE THE CURRENT COSTS(RS)
    3.00    4.50    1.75    5.00
   WANT TO CHANGE ANY OF THESE?(Y/N):
>N
  currently the inventory policy is maintaining the following
  days' demand as stock for each product respectively.
    15.    15.    15.    15.    15.
  Do you want to see the effect of changes in this policy?
  press Y for YES & N otherwise
>Y
  TYPE IN THE NEW POLICY IN TERMS OF DAYS IN ORDER OF PRODUCTS
(i)?15  10  6  4  2
  Currently the upper limits on overtime,lay-off
  and new hiring of labour hours are:
  70000.  70000.  70000.
  Do you want to impose any OTHER limits on them?(Y/N):
>Y
  TYPE THE LIMITS IN ORDER.IF YOU DO NOT WANT TO ALTER
  LIMITS OF ANY OF THEM TYPE 1 AGAINST THAT CATEGORY
(i)?20000  30000  0
  At present,allowed overloading on machines is 60.00%
 want to alter this?(Y/N)
>N
```

THE PRODUCTION VOLUMES FOR THE NEXT PERIOD(YEAR) ARE:

PRODUCT 1= 5455.

PRODUCT 2= 5218.

PRODUCT 3= 3883.

PRODUCT 4= 3673.

PRODUCT 5= 2229.

INVENTORIES AT THE END OF NEXT PERIOD ARE:

PRODUCT 1= 226.

PRODUCT 2= 144.

PRODUCT 3= 64.

PRODUCT 4= 41.

PRODUCT 5= 12.

REQD. REGULAR LABOUR-HOURS: 257974.8

REQD. OVERTIME-HOURS: 0.0

NO OF LAY-OFF HOURS: 19900.0

NO OF NEW LABOR-HRS HIRED: 0.0

TOTAL COST OF PROD.& INV. HOLDING = Rs 8060938.83

CAPACITY UTILIZATION(PERCENTAGE):

LABOUR 71.39

MACHINE128.35

You can directly go to FINANCIAL ANALYSIS from here.

In case you want to modify some of the coefficients

in the L.P formulation ,you can try.press Y to try else press N

>N

Let me show you the INCOME STATEMENT and different RATIOS

for analysis

INCOME STATEMENT

~~~~~~~~~~~~~~~~

	PROD 1	PROD 2	PROD 3	PROD 4	PROD 5
VOLUME OF SALES	5499.	5264.	3899.	3797.	2256.
PRICE/UNIT(RS)	219.99	290.00	650.00	390.00	1493.50
REVENUE	1209884.76	1526652.78	2534542.17	1480895.72	3370592.83
COST OF GOODS SOLD	1172553.19	1213460.78	2108453.81	1057959.15	2729553.87
PROFIT BEFORE TAX	37331.57	313192.01	426088.36	422936.56	641038.93
TAX(55.%)	20532.36	172255.60	234348.60	232615.10	352571.42
NET PROFITS	16799.21	140936.40	191739.77	190321.45	288467.52
RETURN ON SALES	1.38	9.23	7.56	12.85	8.55
CONTRIBUTION PER LABOUR-HR (Rs):	1.13	4.10	9.10	6.75	14.94
CONTRIBUTION PER MACHINE-HR (Rs):	0.96	26.44	15.61	17.[illegible]	31.56
~~~~~~~~~~~~~~~~

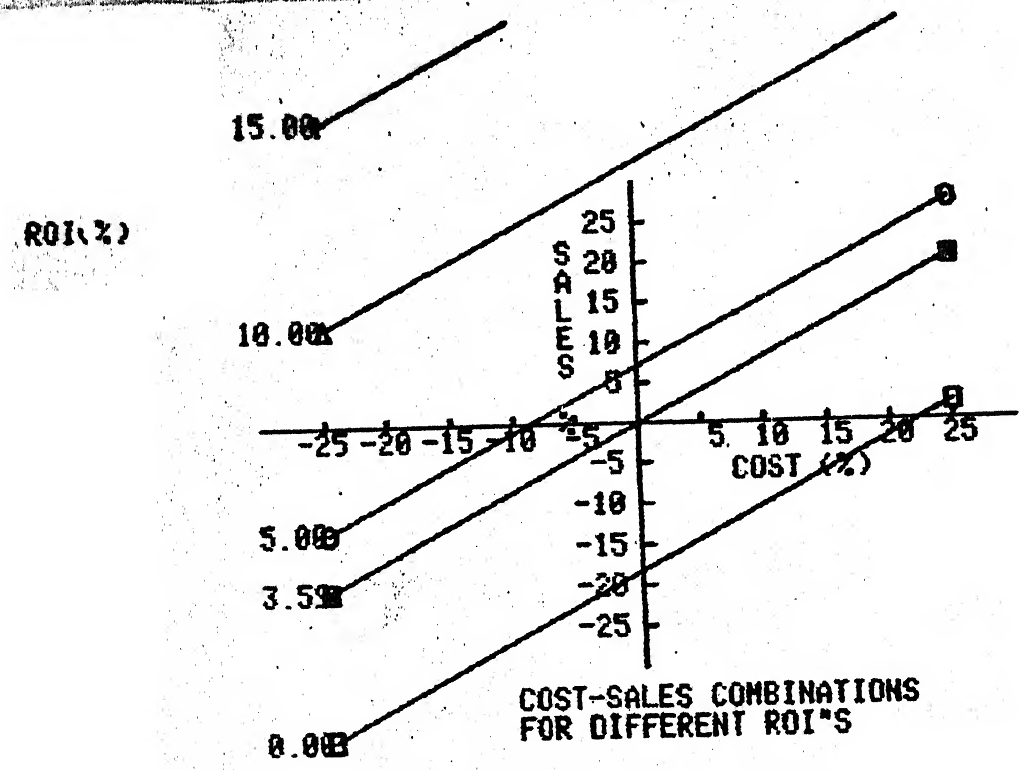
TOTAL REVENUE	RS	1012[illegible]
TOTAL COST OF GOODS SOLD	RS	82819[illegible].75
TOTAL PROFIT BEFORE TAX	RS	1840587.47
TOTAL [illegible]	RS	1012323.[illegible]
TOTAL NET PROFIT	RS	828264.37
OVERALL RETURN ON SALES(%)		8.18
RETURN ON INVESTMENT(ROI) %		3.59
FINISHED GOODS TO SALES RATIO		0.01
INVENTORY ASSETS	RS	142642.62

Are you satisfied with this level of ROI?

In case you are not and you want some other level of ROI the following graph will help you in either increasing sales or decreasing costs as % over the figures you are currently working with, to set different levels of ROI

C. TO CONTINUE

>C



DO YOU WANT TO WORK AGAIN OR WANT TO QUIT?(W/Q)

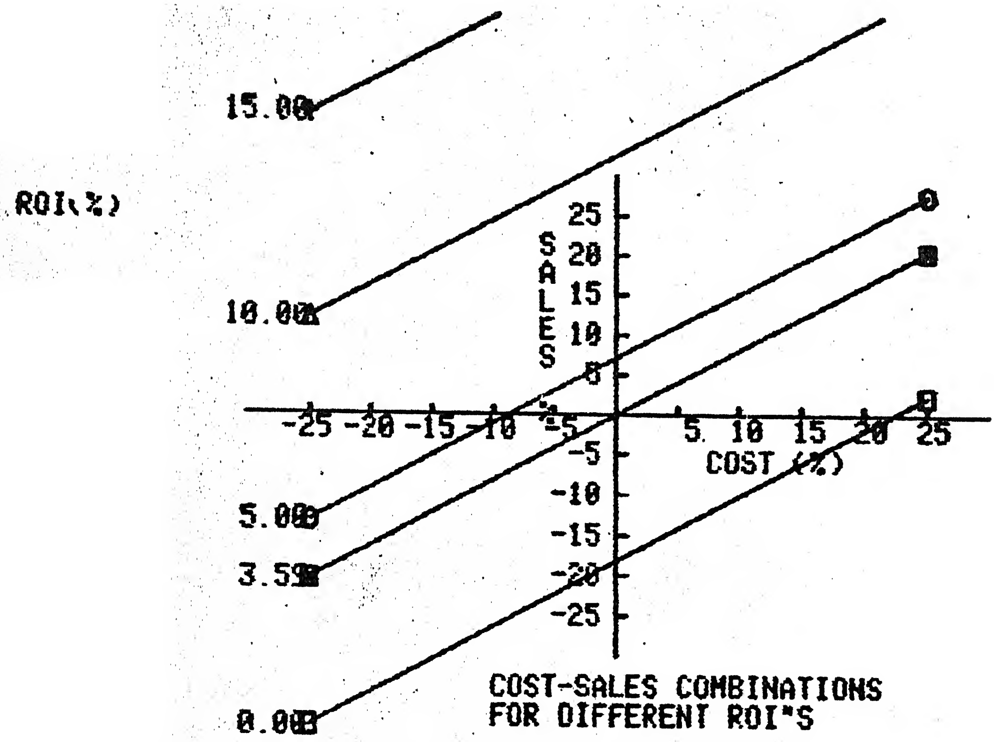
>Q

EXIT

In case you are not and you want some other level of ROI the following graph will help you in either increasing sales or decreasing costs as % over the figures you are currently working with, to set different levels of ROI.

C. TO CONTINUE

>C



DO YOU WANT TO WORK AGAIN OR WANT TO QUIT?(W/Q)

>Q

EXIT

DATE SLIP

This book is to be returne
the date last stamped.